Overview

- Advances in Freight Forecasting
  - Supply Chain Models
  - Tour-based Models
  - Hybrid Models

- FHWA Research on a Freight Forecasting Framework

- Recommendations for a Goods Movement Framework
  - Statewide/National
  - Regional/Urban
Advanced Freight Forecasting Methods

Supply Chain Models
- Tend to be National in scope
- Some examples at State and Regional levels

Tour-based Models
- Tend to be Regional in scope
- Some examples at State and National levels

Hybrid Models
- Combined supply chain and tour-based models
- Tend to be for Regional planning purposes, but with a National component
U.S. FAME Framework

**FAME**
**FREIGHT**
**ACTIVITY**
**MICROSIMULATION**
**ESTIMATOR**
1. All the firms in the study area are recognized and their basic characteristics are identified.

2. Based on each firm’s characteristics, the types and amounts of incoming and outgoing goods are determined, and the design of the supply chains is replicated.

3. The shipment sizes are defined based on the acquired information on the firms’ characteristics and the way that they trade commodities between each other.

4. Shipping decisions such as shipping mode, haul time, shipping cost, warehousing, etc. are made.

5. The impact of the goods movements on transportation network is investigated.

Source: Amir Samimi, Abolfazl (Kouros) Mohammadian and Kazuya Kawamura
Norway and Sweden National Freight Models

- Similar (but separate) models for each country
- Logistics costs for each leg of production-consumption (PC) flow are simulated on a firm-to-firm level
- Feedback allows logistics choices to impact economic (trade) patterns

Source: Gerard De Jong and Moshe Ben-Akiva
Texas Urban Commercial Vehicle Model

- Data are from the Texas Commercial Vehicle Surveys in San Antonio, Amarillo Valley, Lubbock and Austin during 2005 and 2006, which included 13,802 trips made by 1,711 commercial vehicles.

- Models daily tour choice with a joint discrete choice model.

- Each tour is defined as the entire trip chain in a given day.

- Schedule choices for each tour are classified into 8 classes defined by: vehicle type, departure time, and trip chaining pattern/topology.

Source: Minyan Ruan, Jie (Jane) Lin and Kazuya Kawamura
<table>
<thead>
<tr>
<th>Model Type</th>
<th>Strengths</th>
<th>Weaknesses</th>
</tr>
</thead>
</table>
| Supply Chain     | • Representation of complex relationships between suppliers, shippers, transshipment points, and consumers;  
                   • Good at representing economic drivers and commodity demand systems | • Variability in relationships makes generalization difficult;  
                   • Supporting data difficult to obtain;  
                   • Missing service-purpose movements |
| Tour-Based       | • Good at representing service vehicle movements and local deliveries in urbanized areas | • Misses inter-city shipments and ties to economic and commodity demand systems |
| Hybrid           | • Combines the best of both model types                                   | • Comprehensive data difficult to obtain                                                              |
Freight Forecasting Framework National Scope

- County Business Patterns
- Firm Synthesis
- Firms by Industry Type and Emp Size By CMAP Zones
- Supply Chain and Goods Demand
- Macro-economic I/O Tables
- Annual Commodity Flow Data for US
- Shipments by Distribution Channel (4)
- Shipments for each Buyer-Supplier Pair
- Distribution Channels
- Shipment Size and Type
- Production Mode and Intermodal Transfers
- Networks (Line-haul distance, Access, Egress, Cost, Mode, Transfer Facilities)
- Truck Flows
- Rail Flows
- Water Flows
- Air Flows
Firm Synthesis

- Firms are synthesized for the entire U.S. with a high level of industrial sector detail, and across several employment categories.

- Spatial resolution is more detailed than is used nationally (counties are smaller than FAF zones).

- Spatial resolution is less detailed than is used regionally as counties are larger than the CMAP mesozones. Allocation from Counties to mesozones is based on mesozone employment.
<table>
<thead>
<tr>
<th>NAICS Groups</th>
<th>1-19</th>
<th>20-99</th>
<th>100-249</th>
<th>250-499</th>
<th>500-999</th>
<th>1,000-2,499</th>
<th>2,500-4,999</th>
<th>Over 5,000</th>
<th>Total</th>
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<tbody>
<tr>
<td>Agriculture</td>
<td>631,703</td>
<td>83,328</td>
<td>11,941</td>
<td>2,897</td>
<td>954</td>
<td>382</td>
<td>46</td>
<td>13</td>
<td>731,264</td>
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<tr>
<td>Mining\Construction</td>
<td>774,697</td>
<td>73,607</td>
<td>10,090</td>
<td>3,711</td>
<td>2,363</td>
<td>1,900</td>
<td>1,744</td>
<td>1,716</td>
<td>869,828</td>
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<tr>
<td>Manufacturing</td>
<td>228,381</td>
<td>74,451</td>
<td>18,942</td>
<td>6,170</td>
<td>2,384</td>
<td>828</td>
<td>143</td>
<td>49</td>
<td>331,348</td>
</tr>
<tr>
<td>Transportation\Wholesale\Retail</td>
<td>1,518,135</td>
<td>214,956</td>
<td>34,082</td>
<td>7,305</td>
<td>1,536</td>
<td>393</td>
<td>71</td>
<td>34</td>
<td>1,776,512</td>
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<td>Information\Finance\Professional Services</td>
<td>2,094,868</td>
<td>186,140</td>
<td>32,431</td>
<td>10,141</td>
<td>4,336</td>
<td>1,737</td>
<td>295</td>
<td>97</td>
<td>2,330,045</td>
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<tr>
<td>Education\Healthcare</td>
<td>731,344</td>
<td>110,504</td>
<td>20,120</td>
<td>4,523</td>
<td>2,168</td>
<td>1,748</td>
<td>435</td>
<td>157</td>
<td>870,999</td>
</tr>
<tr>
<td>Entertainment\Recreation\Food</td>
<td>558,052</td>
<td>186,140</td>
<td>11,069</td>
<td>1,522</td>
<td>576</td>
<td>269</td>
<td>43</td>
<td>15</td>
<td>757,686</td>
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<tr>
<td>Other Services</td>
<td>694,640</td>
<td>45,377</td>
<td>3,409</td>
<td>548</td>
<td>163</td>
<td>40</td>
<td>12</td>
<td>3</td>
<td>744,192</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>7,231,820</strong></td>
<td><strong>974,503</strong></td>
<td><strong>142,084</strong></td>
<td><strong>36,817</strong></td>
<td><strong>14,480</strong></td>
<td><strong>7,297</strong></td>
<td><strong>2,789</strong></td>
<td><strong>2,084</strong></td>
<td><strong>8,411,874</strong></td>
</tr>
</tbody>
</table>
Supplier Selection Results

- The model builds 2.8 million buyer-supplier pairs with one of the pair in the Chicago region.
- The distance distribution of buyer-supplier pairs reflects the spatial distribution of commodity flows.

**Distance Distribution of Buyer-Supplier Pairs**
Includes pairs with one or more firms in the Chicago region.

- Peak at <100 miles is within region travel.
- Peak at 600-800 miles is largely to/from east coast (NYC, NJ, PA, DC), and also Texas cities.
- Peak at 1700-1800 miles is Chicago to/from Los Angeles.

**Great Circle Distance (miles)**
- 0-100
- 100-200
- 200-300
- 300-400
- 400-500
- 500-600
- 600-700
- 700-800
- 800-900
- 900-1000
- 1000-1100
- 1100-1200
- 1200-1300
- 1300-1400
- 1400-1500
- 1500-1600
- 1600-1700
- 1700-1800
- 1800-1900
- 1900-2000
- > 2000

- All Commodities
- Food
- Manufactured Goods
Shipment Size and Frequency Models

- Small shipments (<1,000 lb) make up the largest proportion of shipments

- There is relatively little variation between the commodities: a slightly higher proportion of food shipments are small

- Annual shipment frequency is calculated by dividing the annual flow for each supplier-buyer pair by the shipment size

![Distribution of Shipment Size](chart1.png)

![Annual Delivery Frequency](chart2.png)
Mode and Transfer Movements

- Within Chicago movement is all via truck

- Longer movements include significant intermodal elements, including conversion between (for example) FTL and LTL
National Model Sequence

Mode: Air, Rail, Water, Truck?

Buyer at Chicago county 17031
Food manufacturing

Assume last transfer facility always locate in Chicago
Shipment size: 1K ~ 10K lbs
Actual Weight: 5,500 lbs
Annual Frequency: 167

Mode: Truck

Distribution Channel:
One of Distribution Center, Warehouse, or Consolidation Center used

Annual Tons: 464 T
Commodity: Plastics and Rubber

Seller at FAF3 zone 34
Petroleum and coal products manufacturing
Freight Forecasting Framework Regional Scope

- Networks (Line-haul distance, Access, Egress, Cost, Mode, Transfer Facilities)
- Production Mode and Intermodal Transfers
  - Truck Flows
  - Rail Flows
  - Water Flows
  - Air Flows
  - Rail Trip Tables
  - Truck Trip Tables by TOD
- Regional Vehicle/Tour Pattern Choice
- Stop Sequence
- Stop Duration
- Delivery Time of Day
- Number of Stops
- Number of Tours Choice
- Vehicle/Tour Pattern Choice
- Empty Trucks
- Network (Line-haul distance, Access, Egress, Cost, Mode, Transfer Facilities)
Daily Shipments and Warehouse Selection

- Convert annual to daily shipments
- Assign shipments to a warehouse/distribution center
- Identify warehouse/distribution center locations from the synthesized business establishments
Vehicle Choice/Tour Pattern Results

- Results produce the majority of tours using smaller 2 axle trucks

- There are slightly fewer peddling tours than direct tours
Number of Tours and Stops

- The model allocates most shipments to single tour patterns
- Larger shipments are most likely to be in multiple tour patterns
- There is a long tail of tours with many stops (this is discussed in more detail later in the presentation)
Stop Duration

- The model predicts that stops will generally be short on peddling tours and long on direct tours.
Regional Model Sequence

Tour Time of Day and Trip Time of Day

Trip Time of Day (Following trip)
5:52 AM (Derived from travel time, stop duration and previous starting time)
22.5 Minutes

Tour Time of Day (First trip)
5 AM (Forecasted)

7:41 PM
37.5 Minutes

1:07 AM
52.5 Minutes

5:13 AM
52.5 Minutes

9:12 AM
11:30 AM
15 Minutes
52.5 Minutes

2:18 PM
2:59 PM
15 Minutes
22.5 Minutes

10:20 AM
11:53 AM
15 Minutes

5:02 AM
8:02 AM
15 Minutes
52.5 Minutes

4:47 PM
Recommendations for FDOT Statewide Models

- Enhance with the supply chain features of the FHWA framework
  - Synthesizing firms and selecting suppliers
  - Segmenting by distribution channels
  - Mode choice can be enhanced by path choice and shipment size and frequency and transfer facility details

- Models could be estimated from existing data sources and calibrated to statewide conditions

- FDOT could support national data collection efforts
Recommendations for FDOT Regional Models

- Build tour-based vehicle models for each region
  - Vehicle type and tour patterns
  - Number of tours and stops
  - Stop duration and time of day

- Models could be estimated from existing data (Texas) and calibrated to local conditions

- Data could be collected for all metropolitan areas in Florida to support model estimation
Data Requirements for Application

- **Freight Analysis Framework data (FAF3)**

- **County Business Patterns**
  - Firms by industry and size
  - Additional data on agriculture and construction employment helpful

- **Macroeconomic Input/Output tables**
  - Producer and consumer connections

- **Modal Networks (Highway, Rail, Air, Water)**
  - Distance, access and egress times, cost
  - Intermodal and transfer facilities
Regional Surveys of Vehicle Tours

- Survey distribution centers and business establishments in the region

- Collect information on the movements of establishment’s fleet over a 24 hour time period

- Collect detailed truck tour information
  - Vehicle type
  - Day and tour pattern
  - Tour timing
  - Location and duration of stops
  - Commodities

- Use supplemental SP survey to estimate values of time
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